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relationship pointing to an increase in sewage pollution at times when the water of the river becomes turbid. The author recommends the use of carbolic acid as described in the employment of solid culture media for the determination of the number of colon bacilli present in surface waters without dilution.

A Few Experimental Data on Hypodermic Injections: S. J. MELTZER, New York City.

From two series of experiments, Meltzer arrived at the conclusions: (1) That the effect of subcutaneous injection depends to a very large degree upon the concentration of the injected fluid, and very little, if any, upon its bulk; (2) that the effect is distinctly increased by a distribution of the injected quantity over several areas. The author employed crystalloid solutions, and restricts his conclusions to this kind of liquids.

The Utility of a Supply of Live Steam in the Laboratory: H. A. HARDING, Geneva, N. Y.

The expense connected with cooking and sterilizing in the bacteriological laboratory is usually great, because of the high cost and low efficiency of gas. As a saving of time and money, the advantage of using steam, generated directly by coal, is obvious. In fitting up the bacteriological laboratory at the New York Agricultural Experiment Station, the following devices have been tried and found satisfactory: In the case of the Arnold sterilizer, a steam pipe was introduced through the wall of the passage in which the steam normally rises into the sterilizing chamber, and an elbow screwed to the end of this pipe and turned downward. With this connection, the Arnold can be brought to a temperature of 99° C. within five minutes, without any unpleasant noise or undue waste of steam. An autoclave was constructed, differing from

the ordinary type in that steam was introduced from a high pressure boiler. By means of a reducing valve the steam pressure and, consequently, the temperature within the autoclave, can be held within very narrow limits. A ten-minute exposure at 120° C. suffices to render tubes of gelatin and other media sterile. Steam cups were installed, having the shape of an ordinary water-bath, except that their depth was considerably increased. A steam inlet was placed at the bottom, and a waste pipe provided for carrying off the condensation. In these cups water is heated and agar is melted much more quickly than it could be done over an ordinary Bunsen burner, and in cooking media there is no possibility of boiling over or burning. The above pieces of apparatus, together with the hot air sterilizer, are placed upon an eight-foot bench, and nearly all the heat radiated is carried off by a galvanized iron hood. These devices have been in use for nearly two years and are giving good satisfaction.

H. W. CONN,
Secretary.

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS FOR THE YEAR ENDED JUNE 30, 1900.

THE Secretary of Agriculture has recently transmitted to Congress the annual report on the work and expenditures of the Agricultural Experiment Stations, made by A. C. True, Director of the Office of Experiment Stations. The following paragraphs are taken from the introduction to this report:

THE WORK OF THE STATIONS AS RELATED
TO PRACTICAL AGRICULTURE.

In making our examination of the work of the experiment stations during the past year we have particularly inquired whether their operations are conducted with special reference to the agricultural needs of their

respective States and Territories. The results of this inquiry are embodied in the accounts of the individual stations given in this report. From these it will be seen that by far the largest part of the work of our stations has direct relation to the important agricultural interests of the communities in which they are located. The stations are, in fact, very responsive to the immediate demands of their farmer constituencies. Their greatest danger is not that they will undertake too much work of remote practical bearing, but that in the effort to meet the calls made upon them for immediate assistance they will attempt individually to cover more fields of investigation than the funds at their disposal will permit them to treat thoroughly. This temptation the stations generally are, however, resisting more successfully as their work is becoming better organized and their investigations are more carefully planned and supervised. The nature of their operations is also becoming better understood by the farmers, and the desirability of more thorough and far-reaching investigations is much better appreciated than formerly. A broader and deeper foundation of scientific inquiry is being laid each year, and there is a constant accumulation of data regarding the general agricultural conditions of the different regions of the United States. The climate, soil, water supply, native and cultivated plants, injurious insects, fungi and bacteria are being studied in more detail and with greater thoroughness than ever before. The principles of nutrition of animals and the causes of their diseases are being subjected to more elaborate and fundamental scrutiny. Methods of investigation and the improvement of apparatus for research are being given increased attention. Much of this work is done without public observation and in the intervals of other operations. Without doubt it should receive more definite recognition and encour-

agement. But it is cause for congratulation that so much patient labor of this character is being performed by station officers, who, as a rule, are seeking to advance the boundaries of knowledge for useful ends and are not deterred by a multiplicity of duties from giving attention to the more fundamental concerns of agricultural science. And this work is having its effect on the more practical operations of our stations. These are assuming a more substantial and systematic character and are being conducted with more definite relation to actual conditions. They have, therefore, a greater assurance of successful practical outcome. Questions relating to the introduction of plants or to the improvement of the live-stock industry in any region, for example, are now being investigated with a strict relation to the real requirements of the agriculture of that region which would have been impossible a few years ago. The present activity in plant breeding, as distinguished from the indiscriminate testing of varieties, is a good example of the raising of the level of experiment-station work as applied to directly practical ends. The plant breeder now sets definitely before him the kind of variety needed by the farmer in a given region or for a given purpose and applies all his scientific knowledge and practical skill to the production of such a variety. The notable success of some of the efforts in this direction already made are but a foretaste of much wider practical results as knowledge and experience in this line of endeavor increase. To do such work effectively there must be an almost ideal combination of science and practise. And the more we can learn definitely regarding the underlying principles, the more surely shall we be able to make successful practical applications. In such investigations science becomes more practical and art more scientific.

PROBLEMS OF STATION ORGANIZATION.

Much attention has been given during the past year to questions relating to the more perfect organization of the stations. As the stations develop, the importance of a clearer definition of the functions of different officers in administration and investigation becomes more apparent. Conditions which existed when institutions for higher education and research were established in this country have materially changed, and the old forms of organization are now, in many cases, a serious hindrance to their best development. For example, the theory on which the laws relating to the governing boards of many of the State colleges and experiment stations are based is that the board is to have the direct control and management of the institution. For this purpose it is to meet frequently, keep the details of the business of the institution well in hand, consult freely with officers of various grades and pass rules and regulations governing every operation. This may, perhaps, have been well enough when the institutions were in a formative period and trained executive officers were scarce, but to-day this theory is out of date and its application to the intricate and specialized business of our colleges and stations is highly injurious to their best interests. It works just as badly when applied to a college or experiment station as it would in the case of a railroad or a bank. The fact is that boards of control are most useful when their functions are confined to a broad, general supervision of the policy, finances and work of the institution and the choice of its chief officers. For this purpose annual or semi-annual meetings would ordinarily be sufficient, since the number of matters requiring the attention of the board should be reduced to a minimum. The best reason for the continuance of such boards is that when composed of broad-minded and successful citizens they

represent the best sentiment of the community regarding these institutions, and are able to give the public an adequate guaranty for the wise and liberal management of the great interests involved in the State colleges and universities. Otherwise it would probably be best to do away with the boards and make the heads of the colleges directly responsible to some State officer of high rank. One especially annoying and unjustifiable feature of the present system is the maintenance at many of the colleges of an officer, commonly designated secretary of the board, who acts as a representative of the board in the intervals between their meetings and exercises important functions relating to the business of the institution independently of its president. There is thus divided responsibility in the daily administration, and in case of friction between the president and faculty or students often a convenient center for discontent and disloyalty is ready at hand. All the legitimate functions of a secretary of the board might easily be performed by a registrar or other officer attached to the president's office, and thus an important 'rock of offense' might be removed from the administrative systems of these institutions.

The successful college president is no longer preeminently a great scholar, but rather a broad-minded and well-trained man of affairs, understanding the requirements of modern educational and scientific institutions and able to administer the affairs and manage the personnel of such institutions. He will look to his governing board for advice and counsel on the larger matters of general policy, but he ought not to have their intervention in the details of the business. To his hands should be fully committed the administration of the whole institution, and his work should be judged with reference to its successful issue. There should be no doubt in the mind of any offi-

cer connected with the institution that he is responsible to the president for his official conduct, and that an appeal to the board can be made only in extreme cases.

The institution will naturally be divided into a limited number of departments, at the head of each of which will be placed an officer competent to plan and manage the business of the department intrusted to his charge. The amount and character of the administrative duties which these officers will be called upon to discharge will vary with the nature of the department. The agricultural experiment station is by law to be organized as a department of the college with which it is connected. It differs from the ordinary college department in being charged with the work of investigation rather than instruction and in having definite relations with a great industry for whose promotion it is especially established. Through its correspondence, publications, inspection service and association with the farming community it has an increasing amount of business not immediately relating to its investigations, but requiring special knowledge and skill for its successful discharge. To do most effective work the operations of the station must proceed in accordance with a well-matured plan which involves the cooperation of different members of the staff. So extensive and important has the business of the stations become that their proper management requires the time and energy of an executive officer, or director. In some cases it may still be possible for the director to conduct investigations in some special line or do a limited amount of teaching, but as a rule he can do little beyond attending to administrative duties. In a number of institutions prudential reasons of various kinds have led to the combination of the offices of president and director. Whatever justification there may have been for this in the past there is little excuse for it in the present. The du-

ties of a college president are too multifold and onerous to permit his giving much attention to the special needs of an experiment station. His directorship almost necessarily becomes a nominal affair and the general business of the station is actually performed by some one member of the staff or distributed in a desultory way among a number of subordinate officers. This arrangement has not worked well and should be universally abandoned.

As regards the business of the station, the director should be clothed with a large measure of authority and consequent responsibility, should plan and supervise its work and expenditures, and control its staff to such an extent as will bring them together to work as a unit for the promotion of the station's success. The members of the staff should be directly responsible to the director on all matters relating to the station, whatever their position may be in other departments of the college, and should expect to transact station business through the director rather than through the college president or the governing board. A proper independence in the conduct of investigations, or parts of investigation, in their respective specialties, and just credit for their share in the station's operations as set forth in publications or otherwise may, it is believed, be amply secured for the expert officers of the stations at the same time that good discipline is maintained and ample provision made for united effort.

No class of men need to readjust their professional code to the modern requirements of the organization of great scientific and educational enterprises more than college professors and scientific specialists. A way must be found by which teaching and research can be conducted on a system which combines liberty with law. The old régime of the entirely independent teacher and investigator has passed away. The specialization which is simply a form of the

division of labor well known in industrial pursuits carries with it a necessity for combination of workers in educational and scientific institutions, as well as in manufacturing establishments. In a way hitherto unknown, scientific men will be called in the future to work together for common ends. No matter is of more vital importance in the organization of our colleges and experiment stations than the securing of harmonious and concerted action on the part of faculties and staffs for the common good of the institution to which they are attached. One of the greatest difficulties now attending the successful management of these institutions is the fact that while specialization has narrowed the field and outlook of the individual officer, there has not been a corresponding recognition of the necessity of readjusting the form of organization and the spirit of the worker to meet these new conditions. At no time has there been greater need of the cultivation of an earnest and enthusiastic *esprit du corps* among the rank and file of educational and scientific workers. There are many individual examples of men impressed with this lofty sentiment, but the whole body is not yet animated with it. Obviously it should especially be a virtue characteristic of men connected with public institutions. The officers of our agricultural colleges and experiment stations are public functionaries employed to advance very important public interests. With them the good of the community, as involved in the success of the enterprise with which they are connected, should be the ruling motive of action. The fame and emoluments of the individual worker should be subordinated to the requirements of concerted action for a common end. And yet in the long run it is believed the individual worker as well as the institution will profit by a loyal and self-sacrificing discharge of common duties, for union of effort will bring greater success;

and whenever a college or a station is strong and flourishing, credit is reflected on every worker who has contributed to this issue.

The general considerations affecting the efficient organization of our experiment stations have thus been dwelt upon because a survey of these institutions during the past year has brought additional evidence that the problems of organization are being more generally considered than ever before. The tide is running strongly toward a more compact organization and a greater unification of the work. On the whole, those stations which have a strong organization and administration are meeting with the largest measure of success.

THE ORIGINAL WORK OF THE STATIONS.

There is also unusual interest in the discussion of problems relating to the functions of the stations and the specific duties of station officers. There is quite general agreement that each station should conduct a considerable amount of original investigation; but in what way this should be provided for and what should be its character are variously regarded. There is still great variety in the assignment of teaching and investigation to officers in different stations, and the relative amount of work of research which is left to assistants differs very greatly in different places. Considerations relating to the financial conditions of college and station still affect the assignment of work in a number of institutions. Our observation of the situation leads us to the belief that there is actually going on a widespread differentiation of the investigator from the teacher, and that this is not prevented, though it may be hindered, by the varying arrangements made at the colleges and stations. A certain number of men are more and more devoting themselves to the work of investigation, and succeeding in it. Others are just as certainly losing their interest and activity in

such work. Because a man is required to teach many hours he does not thereby become a successful teacher. The research which he is compelled to carry on during vacations and at night may nevertheless be his real mission, and it will be well if his superiors discover this. The leaving of details of research work to assistants often means that the principal has largely lost his interest in it or considers other duties more important. We are getting an increasing body of competent investigators by this process, though in too many cases their training is proceeding under untoward conditions. It will be well if boards and presidents will consider more fully the actual state of things and make as far as possible such a readjustment that the investigator will be left very largely to investigate and the teacher to teach. It continues to be a weakness of a considerable number of our stations that they are organized on too broad a scale for their resources. Too great a portion of their funds is going into salaries, leaving too little to pay the miscellaneous expenses of important investigations. Here and there only have the authorities had the wisdom and courage to confine the operations of the station within comparatively narrow lines, leaving important departments of work entirely without recognition. It is encouraging, however, to observe that where this has been done success has brought additional funds with which the scope of the station's work could be safely extended.

On the whole, the amount of what may fairly be called original investigation is, in our opinion, steadily increasing. To determine this it is not sufficient to consider simply the bulletins of the stations. These have in various ways been made more popular in form and matter. A larger amount of the more original work is being recorded in the annual reports and the records of more investigations are being withheld from pub-

lication until results of value are obtained. While there is still need of urging the advancement of the general standard of investigations, there is every reason to believe that our stations are moving onward and upward as agencies for the original investigation of agricultural problems.

THE INSPECTION SERVICE OF THE STATIONS.

The amount and variety of inspection service required of our experiment stations continue to grow from year to year. Beginning with commercial fertilizers, it now includes feeding stuffs, dairy products and other foods for man, creamery glassware, insecticides, nursery stock for injurious insects, and plant and animal diseases. For a considerable period this matter affected only the stations in the East, where commercial fertilizers were largely used, but it is now a live question in all sections of the country, since there is no region which does not have some evil against which the agricultural public is demanding protection by inspection under State or national auspices. Questions relating to the attitude of the stations toward this work are therefore engaging the attention of station officers throughout the country. Wherever this work has assumed considerable magnitude it is evident that it requires very careful organization in order that it may be conducted so as not to interfere with the work of investigation. Where the same officers are charged with both kinds of work there is constant danger that the severe routine duties of the inspection service will diminish the ability of these officers to conduct thorough original investigation. It is essential that there should be a distinct differentiation of this service from the other work of the stations as regards both funds and time of performance. Unless this is done and close supervision is exercised, the inspection work is inevitably a drain upon the resources of the station

and a hindrance to its more important operations. While our stations have from the beginning been engaged in inspection work, and this has met with increasing popular favor because of its efficient performance, it is still doubtful whether it is the best ultimate arrangement. Almost all our experiment stations are organic parts of educational institutions. As such they are essentially university departments devoted to research and to the dissemination of new knowledge. To a certain extent they may naturally and properly engage in the various forms of university extension work through their more popular publications and connection with farmers' institutes, etc. They are organized to conduct investigations on a great variety of subjects, and the scope of their work of investigation can be almost indefinitely extended as their funds increase. They do not need, therefore, to go outside of that work which would be universally considered within their rightful domain as departments of colleges and universities in order to secure a wide field of operation. On the other hand, as the range of inspection service enlarges and its duties become more onerous and complicated it becomes very questionable whether this service should be connected with our educational institutions. It is essentially a part of the police functions of the State and National Governments. It involves many questions on which sooner or later the courts will have to pass. It may even excite public attention to such an extent as to be reckoned worthy of consideration by the people in their choice of administrative and legislative officers. In many ways this kind of business is much more appropriate to bureaus of the State government than to educational institutions.

Thus far the arrangement by which much of it has been connected with the experiment stations has been largely a matter of convenience, and in many States the amount

of work to be performed has been so inconsiderable that it has not seemed worth while to create special agencies for its performance. We have now reached a stage in the development of this work when it is believed that this matter should receive careful attention from the managers of our agricultural colleges and experiment stations, in order that a sound policy may be established which will provide for the best future development of these institutions. In our judgment, this would involve efforts to relieve the colleges and stations of the inspection service rather than to increase its scope at these institutions and make it a permanent portion of their work.

STATE AID TO THE EXPERIMENT STATIONS.

A number of the States continue to liberally supplement the national funds, and thus to extend and strengthen the investigation of the stations within their borders. This is done by specific appropriations for substations or special investigations, or by general appropriations for the current expenses of the colleges with which the stations are connected. Often the printing of station publications is provided for by the State. During the past year notable additions have been made to the buildings and equipment of the agricultural colleges, and the experiment stations have received much benefit from these increased facilities. At the University of Illinois a building costing \$150,000 has been erected for the use of the agricultural college and experiment station. This will be thoroughly equipped with apparatus and other facilities for instruction, and when completed will form the largest single plant for agricultural instruction and research in this country. At the University of Nebraska a building costing \$35,000 has been erected for the special use of the experiment station. At the Washington Agricultural College a science hall costing \$60,000 has been erected, which provides

greatly improved facilities for the work of the college and station. At the Texas Agricultural College there is a new agricultural and horticultural building costing over \$30,000, and at the Kansas Agricultural College an agricultural building of the same value. At the Oklahoma Agricultural College there are new chemistry and library and science buildings, and at the Virginia Agricultural College and the University of Tennessee new and commodious barns have been erected, each costing about \$5,000. At the latter institution a dairy building has also been constructed. At the Agricultural College of the University of Minnesota a horticultural-botanical building costing \$35,000 has been erected.

It is believed that the successful work of the experiment stations has been a large factor in arousing the attention of the public to the benefits of instruction as well as research in agriculture, and to the importance of equipping the agricultural colleges more amply and giving them increased funds for the extension of their work in both directions. It is well that this fact should be brought to the attention of legislators when appropriations for these institutions are being made. Funds are needed for the extension of investigations as well as for better equipment, and oftentimes a comparatively small sum added to the current revenue of the station will enable it materially to strengthen its work. This is so because the broad organization of our stations requires that a relatively large portion of the national funds must be expended for salaries and wages. This leaves so little for the general expenses of investigations that they can not as a rule be made very extensive. If it is desirable that particular investigations should be conducted on a somewhat extensive scale or in different localities, the State can often secure this desirable result by providing funds for these specific purposes. As regards the investigations which

need to be carried on in different localities, it is, in our judgment, a much wiser policy to give the stations funds for such special investigations than to establish permanent substations, which have universally proved to be relatively expensive and unsatisfactory.

THE DEVELOPMENT OF THE EXACT NATURAL SCIENCES IN THE NINETEENTH CENTURY.*

THE lecture delivered by Van't Hoff, under the above title, although scarcely an hour in length, contains so much important material that a brief account of its contents cannot fail to be of interest to the readers of SCIENCE. The lecture deals only with the sciences of inanimate nature, and, therefore, does not touch any branch of the biological sciences.

Although the question of utility has had much to do with the development of many branches of science, yet the highest aim has not been reached in this way. The sciences have, then, been divided into *theoretical* and *applied*. And we must make the further division into the *general* and the *concrete* or *special* sciences.

The general sciences are dealt with first. These are divided into two classes. First, the *three fundamental mathematical sciences*, which center around the three fundamental conceptions of quantity, space and time. The science of quantity is analysis, including arithmetic, algebra and the higher analysis. The science of dimensions is geometry; while in mechanics, the science of force and movement, time enters as a factor. Second, the two *experimental natural sciences*—physics and chemistry.

Almost an unlimited amount has been accomplished in the nineteenth century in the field of the mathematical sciences. It is only necessary to mention such names

* Lecture delivered by Van't Hoff at the seventy-second meeting of the Society of German Men of Science and Physicians, in Aix-la-Chapelle.